

June 1970

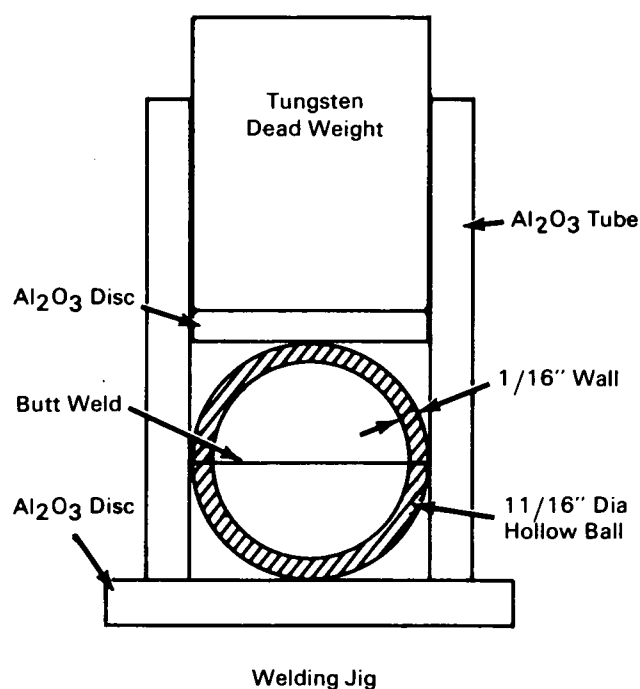
Brief 70-10331

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## Fabrication of Hollow Ball Bearings by Diffusion Welding



possible solution. Experience to date with hollow balls joined by conventional welding techniques has, however, been disappointing. Excess weld metal and/or undercut at the root of the weld proved to be stress raisers. In service, cracking tends to start near the root of the weld, and flexure failures, which originate at the edge of the weld on the inside diameter of the hollow ball, have caused early spalling and even complete fracture of the ball.

It was, therefore, decided to fabricate spherically hollow balls for bearings by butt welding two steel hemispheres in such a manner that there would be no stress raisers, defects, upsets (too much or too little metal in the weld fillet), or unwelded areas. Earlier ball bearings produced by electron beam welding proved to be unsatisfactory and a better welding method had to be developed.

### The solution:

Diffusion weld two steel (AISI-M-2) hemispheres in an atmosphere of  $2 \times 10^{-5}$  torr at a temperature of  $2130^{\circ}\text{F}$  for 4 hours with a pressure of 4 psi (dead weight) holding the hemispheres together. Involved here are two main areas of application for diffusion welding: (1) for materials that cannot be successfully fusion welded by conventional processes; and (2) for welding applications where the weld must be accomplished with only microdeformation (i.e., produce weld joints with no upset material or other discontinuity at the joint).

### How it's done:

The faying surfaces of the two steel hemispheres were lapped to obtain flat surfaces. The hemispheres were assembled as shown in the figure and placed in a

(continued on next page)

### The problem:

Although aircraft gas turbine engine rotor bearings currently operate at fairly high speeds, it is estimated that the engine designs of the next decade will require bearings to operate at twice such speeds. At these high velocities, the reduction in bearing fatigue life due to the high centrifugal forces developed between the rolling elements and outer race becomes prohibitive. To solve the problem of lower fatigue life in high-speed ball bearings, various methods of reducing ball mass to reduce the centrifugal force are being considered. Spherically hollow balls, which are fabricated by welding two hemispherical shells together, offer a

welding jig made of aluminum oxide ( $\text{Al}_2\text{O}_3$ ). A dead weight (tungsten rod) was placed on the upper hemisphere to press the two hemispheres together in the jig and vacuum diffusion welding was accomplished. Metallographic examination of the weldment revealed that complete welding had been achieved. No bond line was evident. Because of the extremely low pressure (4 psi) used, no macrodeformation was produced by the weldment. The ball was spherical in the as-welded condition and no excess material or undercut was present at the joint.

#### Notes:

1. Optimum conditions for this process have not been established, but it appears that good results can be achieved at lower temperatures and with less time at the welding temperature.
2. Low pressure vacuum diffusion welding is an extremely promising joining method for fabricating hollow steel ball bearings, and seems well suited to other joining problems.

3. This diffusion welding method can be used easily with only a vacuum furnace; no loading rams are necessary (as would be necessary for a hot press) since a dead weight is a satisfactory load.
4. Requests for further information may be directed to:

Technology Utilization Officer  
Lewis Research Center  
21000 Brookpark Road  
Cleveland, Ohio 44135  
Reference: TSP70-10331

#### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

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